Elementary Geometry
Session 5

Topic	Activity Name	Page Number	Related SOL	Activity Sheets	Materials
Perimeter And Area, Part I	Dominoes and Triominoes	131	K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4.17, 5.15	One-Inch Grid Paper	Tiles, scissors
	Tetrominoes	134	K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4.17, 5.15	One-Inch Grid Paper, Sorting Mat	Tiles, scissors, paste (optional)
	Pentominoes	137	K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4.17, 5.15	Pentomino Alphabet, Solutions Sheet	Tiles, scissors, and envelopes or plastic baggies
	Areas with Pentominoes	141	K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4,13, 5.10	Pentomino Puzzles, 3 x 5 Solutions, 4 x 5 Solutions, Patterns for Pentominoes 1 and 2	Scissors and envelopes or plastic baggies; or sets of Pentominoes
	Hexominoes	148	K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4.17, 5.15	Hexominoes 1, 2, and 3	Tiles, scissors, grid paper, and envelopes
	Perimeters with Hexominoes	152	K.11, K.12, K.13, 1.16, 2.20, 3.18, 3.20, 4.13, 5.10	Perimeters of Hexominoes	Hexominoes from previous activity
Perimeter And Area, Part II	The Perimeter is 24 Inches. What's the Area?	155	4.13, 5.8, 5.10	One-Inch Grid Paper, One-Half-Inch Grid Paper	24-inch paper strip (collar), 38 one-inch cubes, grid paper
	The Area is 24 Inches. What's the Perimeter?	158	4.13, 5.8, 5.10		24 one-inch squares and grid paper
	Change the Area	159	4.13, 5.8, 5.10	Geoboard Dot Paper	Square geoboard, overhead Geoboard, and rubber bands
Coordinate Geometry	Hurkle	162	4.18	Find The Hidden Hurkle 1, 2, and 3	
	Two-Dimensional Hurkle	166	4.18	Find The Hidden Hurkle Coordinate Grid	

Topic: Perimeter and Area, Part I

Description: Participants will explore the concept of area through the use of "-ominoes" formed by arranging sets of squares. Putting two squares together, with full edges touching forms the domino, the most familiar "-ominoes." Using the "-ominoes" rule (see below), there is only one figure that you can make with two squares. However, by adding squares, other "-ominoes" can be produced. Working with "-ominoes," the participants will have the opportunity to:

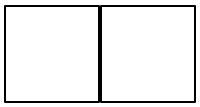
- use spatial visualization to build figures
- develop strategies for finding new figures
- test to find figures that are flips and turns of other figures
- reinforce their understanding of congruence by flipping and turning figures in order to compare them
- use "-ominoes" to fill given rectangular areas
- sort "-ominoes" according to their perimeter and look for patterns in their collected data.

A unit on "-ominoes" can be developed through the use of materials such as color tiles, paper squares, the orange block in the pattern block set, interlocking cubes, or grid paper. Most "-ominoes" activities are best done where children work in groups of two to four, each group with its own set of materials. In that format, groups can explore the various problems independently. All activities should be conducted in an easy-going manner that encourages risks, good thinking, attentiveness and discussion of ideas.

"-Ominoes" Rule:

At least one full side of each tile must touch one full side of another tile.

Touching



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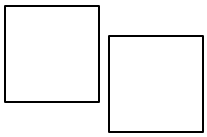

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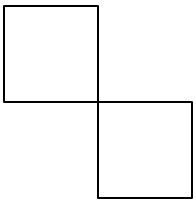


Related SOL: K.11, K.12, K.13, 1.16, 2.20, 2.22, 3.18, 3.20, 4.13, 4.17, 5.10, 5.15

Activity: Dominoes and Trominoes

Format: Large Group/Small Group

Objectives: Participants will use spatial visualization to build "-ominoes" with two and three tiles. They will test to find figures that are the result of flips and turns.

Related SOL: K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4.17, 5.15

Materials: Tiles, scissors, grid paper preferably with the same size squares as the tiles, One-Inch Grid Paper Activity Sheet

Time Required: Approximately 20 minutes

Directions:

1) Show the participants a **domino** and ask them to describe everything they can about the domino. Putting two squares together, with full edges touching forms this figure. There is only one figure that you can make with two squares. Establish that it's made up of two tiles and that each tile must have one side in common with the other tile.

2) Ask the participants if they can find another way to arrange the two tiles so that every tile touches at least one complete side of another tile. They may describe the 90-degree rotation as different. As they discuss their strategies for determining whether or not two figures are the same, you may want to informally introduce the terms *flip* (reflect) and *turn* (rotate) used in transformational geometry.

3) Ask the participants to arrange three tiles in as many ways as possible and to tell something about the figure. Establish that it is made up of three color tiles and that every tile shares at least one complete side with another tile. Tell them that this is called a **triomino**, noting that the "tri" stands for three like in triangle.

4) Ask the participants to find another way to arrange the three tiles so that every tile touches at least one complete side of another tile. Have volunteers who think they have found different figures display them.

5) Model how to record the first figure on grid paper and cut it out. Then have the participants record and cut out their figures. Collect the cutout figures, making two piles, one for each of the two possible arrangements. Show how, by flipping (reflecting) or turning (rotating) the pieces in each pile, you can fit them over each other exactly to make a neat stack.

One-Inch Grid Paper

Activity: Tetrominoes

Format: Large Group/Small Group

Objectives: Participants will use spatial visualization to build "tetrominoes" with four tiles, testing for figures that are flips and/or turns of other figures.

Related SOL K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4.17, 5.15

Materials: Tiles, scissors, paste (optional), One-Inch Grid Paper from previous activity, Sorting Mat Activity Sheet

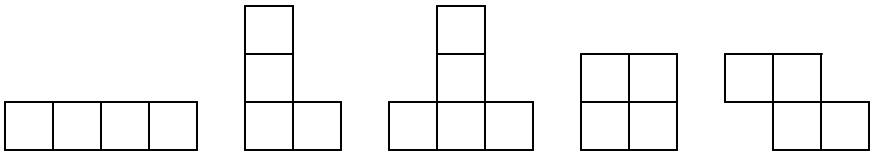
Time Required: Approximately 15 minutes

Directions:

1) Ask the participants to work in pairs. Distribute at least 30 color tiles per pair, scissors, Grid Paper and Sorting Mat Activity Sheets. Ask each participant to make a figure with four color tiles that follows the rule each square tile has one side in common with another square tile. These figures are called **tetrominoes**.

2) Ask the partners to compare their figures. If both made the same figure, have them copy it only once onto the grid paper and cut it out. If they made two different figures, have them copy and cut out both figures. Ask the participants how many different figures they think they can make with four color tiles.

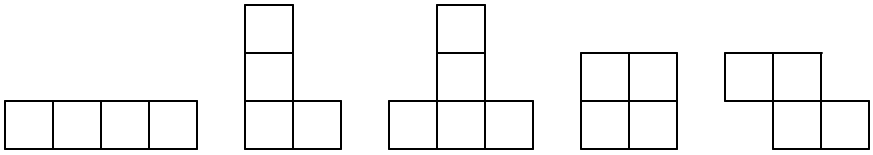
3) Ask the participants to make more figures with four color tiles. Each time they should compare the figures and record and cut out each different figure. The partners should continue until neither can think of any new figures to make and then count all their different figures, recording that number.



4) To promote thinking and sharing, use prompts such as these to promote class discussion:

   - How did you and your partner decide whether or not your figures were different? (Be sure to discuss flips [reflections], turns [rotations], and congruency here.)
   - Did you use any of your old figures to find new ones? If so, how did you do this?
   - How did you know that you found all of the different figures?
   - How many different figures are there? (5)

5) Invite participants to determine which of the tetrominoes are regular and which are irregular. (**Regular tetrominoes** are those that are squares or rectangles, while irregulars are not.)



Regular Irregular Irregular Regular Irregular

This is another way to reinforce the attributes of squares and rectangles. You might contrast this use of the "regular" with its more general meaning. A **regular polygon** is a polygon that has all congruent sides and all congruent angles. So a rectangle is a regular tetromino, but not a regular polygon. A square is both a regular tetromino and a regular polygon. With teachers, be sure to point out that the definition of regular tetromino is actually redundant because since a square is a type of rectangle, it would be enough to say that a regular tetromino is a rectangle. (Ask at what level this distinction should be discussed with students.) Invite participants to come to the front of the class and place their tetrominoes into one of the categories on the Sorting Mat Activity Sheet and give the reason for their decision.

6) Have participants trace or glue their tetrominoes into the appropriate columns on the Sorting Mat Activity Sheet.

Sorting Tetrominoes

Sort your figures into regular tetrominoes and irregular tetrominoes. If an arrangement of squares does not form a rectangle or a square, then it is irregular. Trace or paste the tetrominoes into the proper column below.

Regular Tetrominoes	Irregular Tetrominoes

Activity: Pentominoes

Format: Large Group/Small Group

Objectives: Participants will use spatial visualization to build "pentominoes" with five tiles, testing for figures that are flips and turns of other figures.

Related SOL: K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4.17, 5.15

Materials: Tiles, scissors, envelopes or plastic baggies, One-Inch Grid Paper Activity Sheet (used in Domino and Triominoes Activity), Pentomino Alphabet Activity Sheet, Solutions Sheet

Time Required: Approximately 15 minutes

Directions:

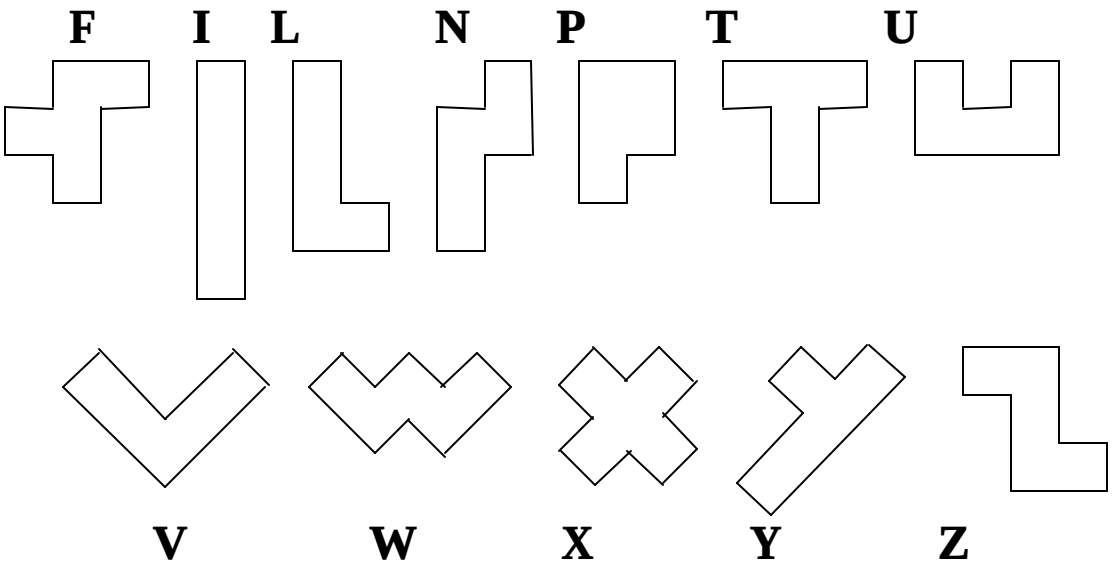
1) Distribute the materials and ask the participants to:
   a) Use five color tiles to find all the possible pentominoes. A **pentomino** is a figure made of five squares, each of which has one side in common with another of the squares.
   b) With a partner, use five color tiles of one color to make a pentomino. Record the pentomino on grid paper. Then make a different pentomino. Continue making and recording pentominoes until you cannot make any more that are different.
   c) Cut out the pentominoes. Compare them by flipping (reflecting) and turning (rotating) them to see if any match exactly. If you find a match, keep only one of them.
   d) Number your pentominoes and put them in an envelope. Write the number on the envelope. Exchange envelopes with another pair of participants. Check their pentominoes to see that none of them are the same. Mark any that you think are exactly the same. Return the envelopes. Check your envelope to see if any duplicates were found.
   e) Discuss ways you could sort your pentominoes.

2) Ask one or two pairs to post their pentominoes in an organized way. Note the organizations, then discuss each of the posted pentominoes. Point out any duplicates and figures that are not pentominoes. Call on volunteers to supply any missing pentominoes.
   Use prompts such as these to promote class discussion:
   - Do you think that you have found all possible pentominoes? Explain.
   - In what ways do the arrangements differ from one another?
   - What strategies did you use to make new pentominoes from your old ones?
   - Did you find any patterns while making your pentominoes? Did you use these patterns when sorting them? How?
   - Did you sort the pentominoes according to the letters of the alphabet that they resemble? (Use Pentomino Alphabet Sheet to illustrate.)
   - Did sorting your pentominoes help you find others that were missing? If so, explain.

3) Ask the participants to predict which figures can be folded to make topless boxes. Have them put their figures into two groups: those that can be folded into boxes and those that cannot.

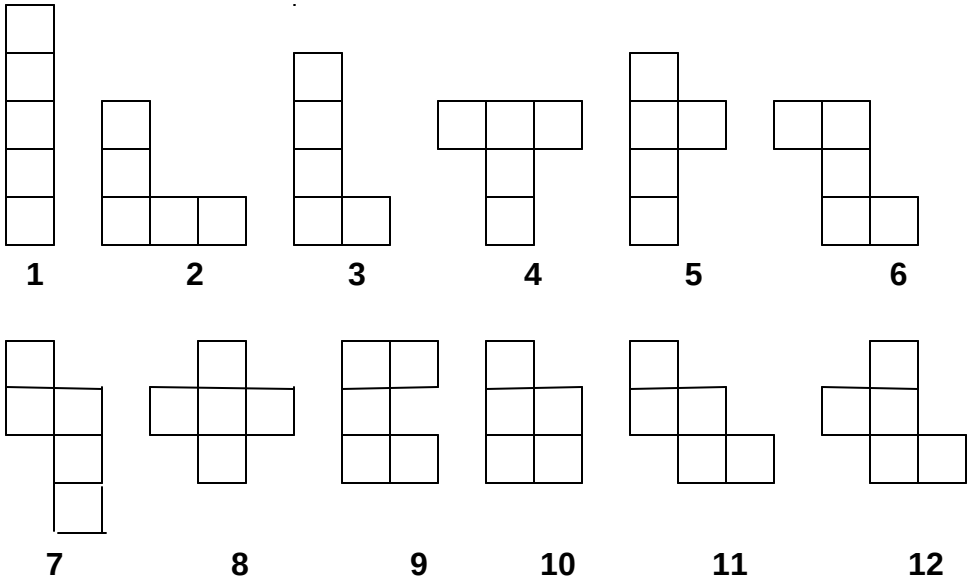
4) Have the participants fold their figures to test their predictions. Share the Solutions Sheet with participants.

The Pentomino "Alphabet"



Solutions Sheet

Which pentominoes fold up into an open top box?



Figures 3, 4, 5, 6, 7, 8, 11, and 12 will fold into an open top box.

Activity: Areas with Pentominoes

Format: Large Group/Small Group

Objectives: Participants will use "-ominoes" to fill given rectangular areas.

Related SOL: K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4,13, 5.10

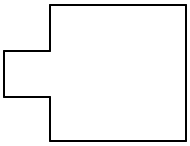
Materials: Scissors, envelopes or plastic baggies or sets of pentominoes made in previous activity, Pentomino Puzzles Activity Sheet, 3 x 5 Solutions Sheet, 4 x 5 Solutions Sheet, Patterns for Pentominoes Sheets 1, 2, and 3

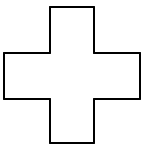
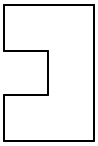
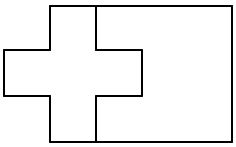
Time Required: Approximately 25 minutes

Directions:

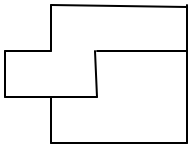
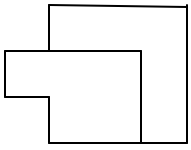
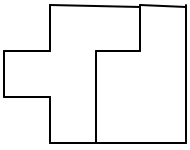
1) Ask the participants to use the pentominoes from the previous activity or have them carefully cut out a set from the Patterns from Pentominoes Activity Sheet.

2) Invite the participants to take their pentominoes and fit them together like jigsaw puzzle pieces. Point out that there are usually several ways to combine pentominoes to fill a given area.

For example,  can be made by combining

 and  like this 

or in several other ways.

3) Distribute the Pentomino Puzzles Activity Sheet and have the participants fill in the 3 x 5 and 4 x 5 areas with pentominoes. Demonstrate an example with the pentominoes. Ask the participants to keep a record of their work on a separate piece of grid paper. Have them compare their results with the Solution Sheets.

4) Ask the participants how many square units there are in each pentomino (five). Ask them to find the pentomino with the largest perimeter and the pentomino with the smallest perimeter. Discuss how figures with the same area can have different perimeters.

5) Ask participants how many square units there are in all 12 pentominoes combined (60). Have them design a symmetrical figure with an area equal to 60 square units and then see if it can be completely filled in with all twelve pentominoes. Share results.

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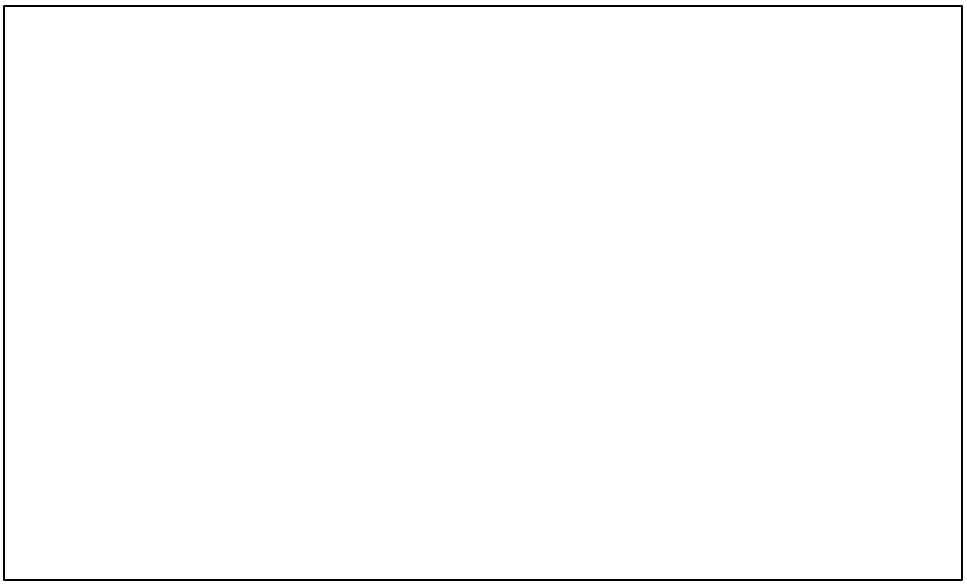
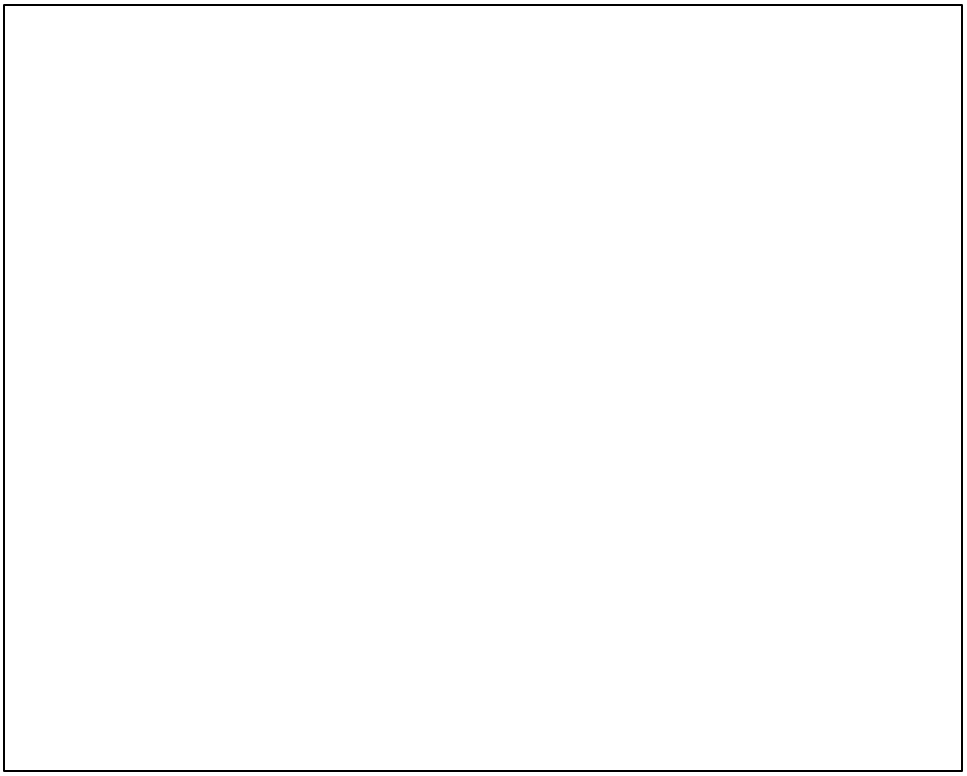
Pentomino Puzzles

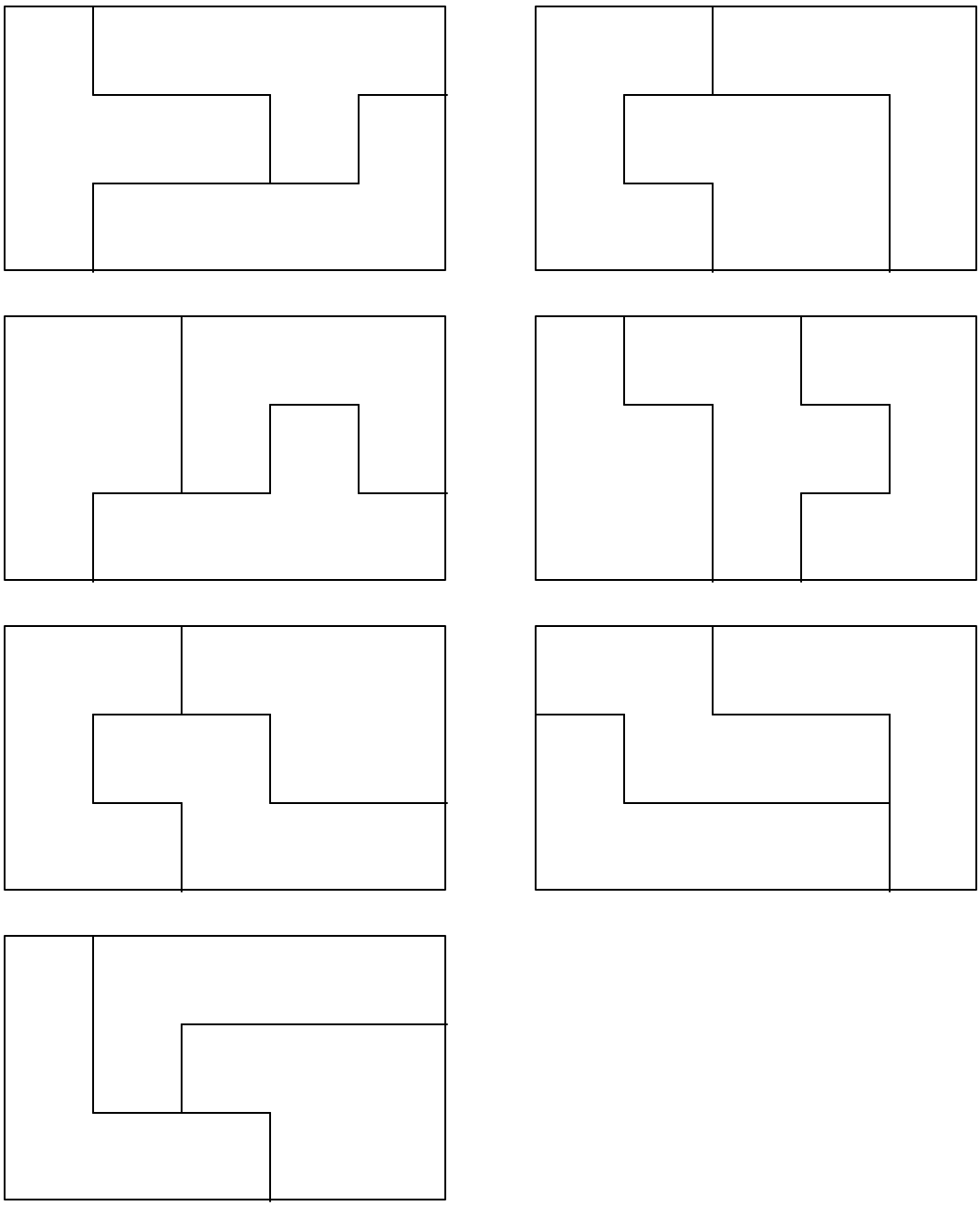


3 x 5

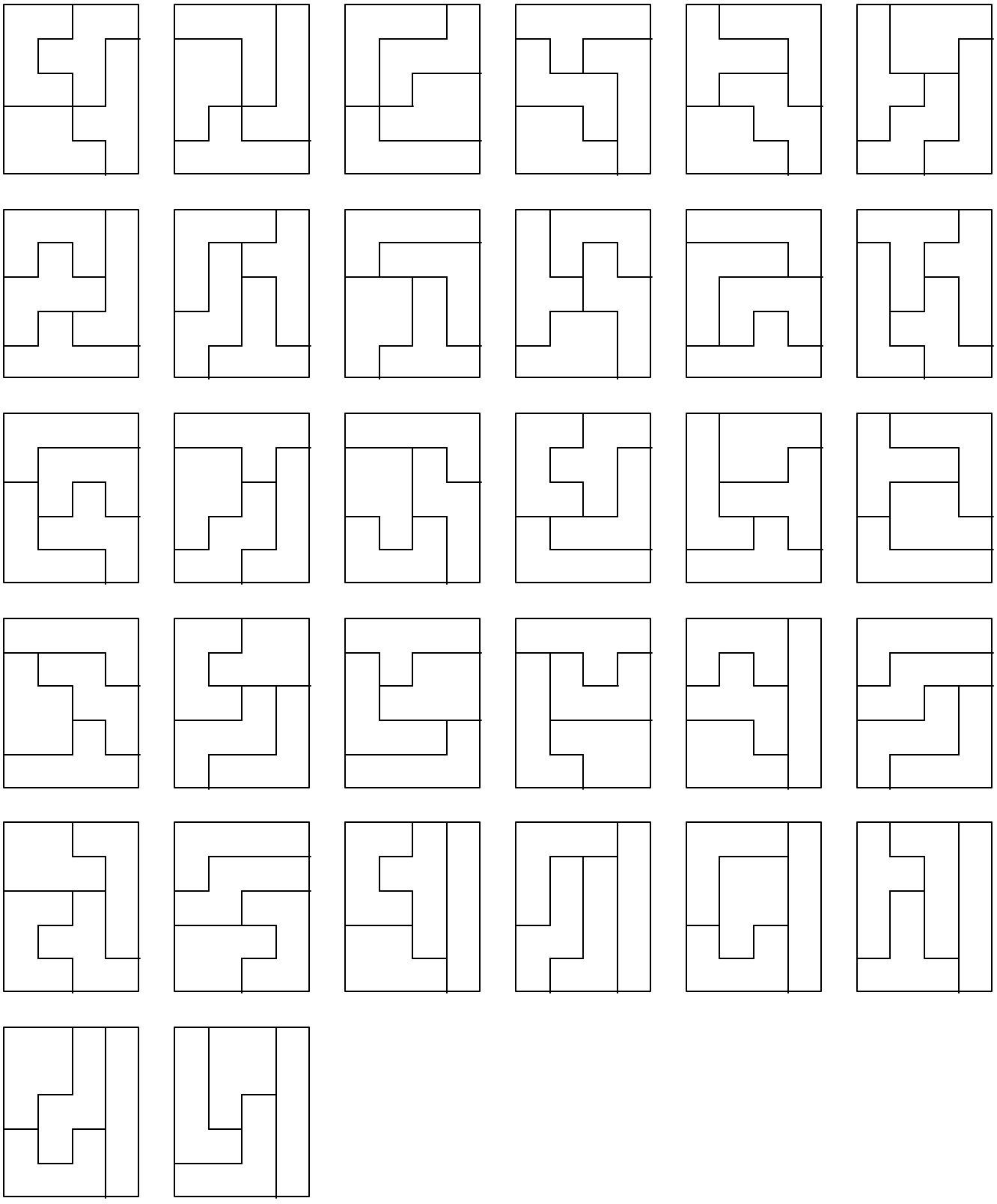


4 x 5

3 x 5 Puzzle Solutions

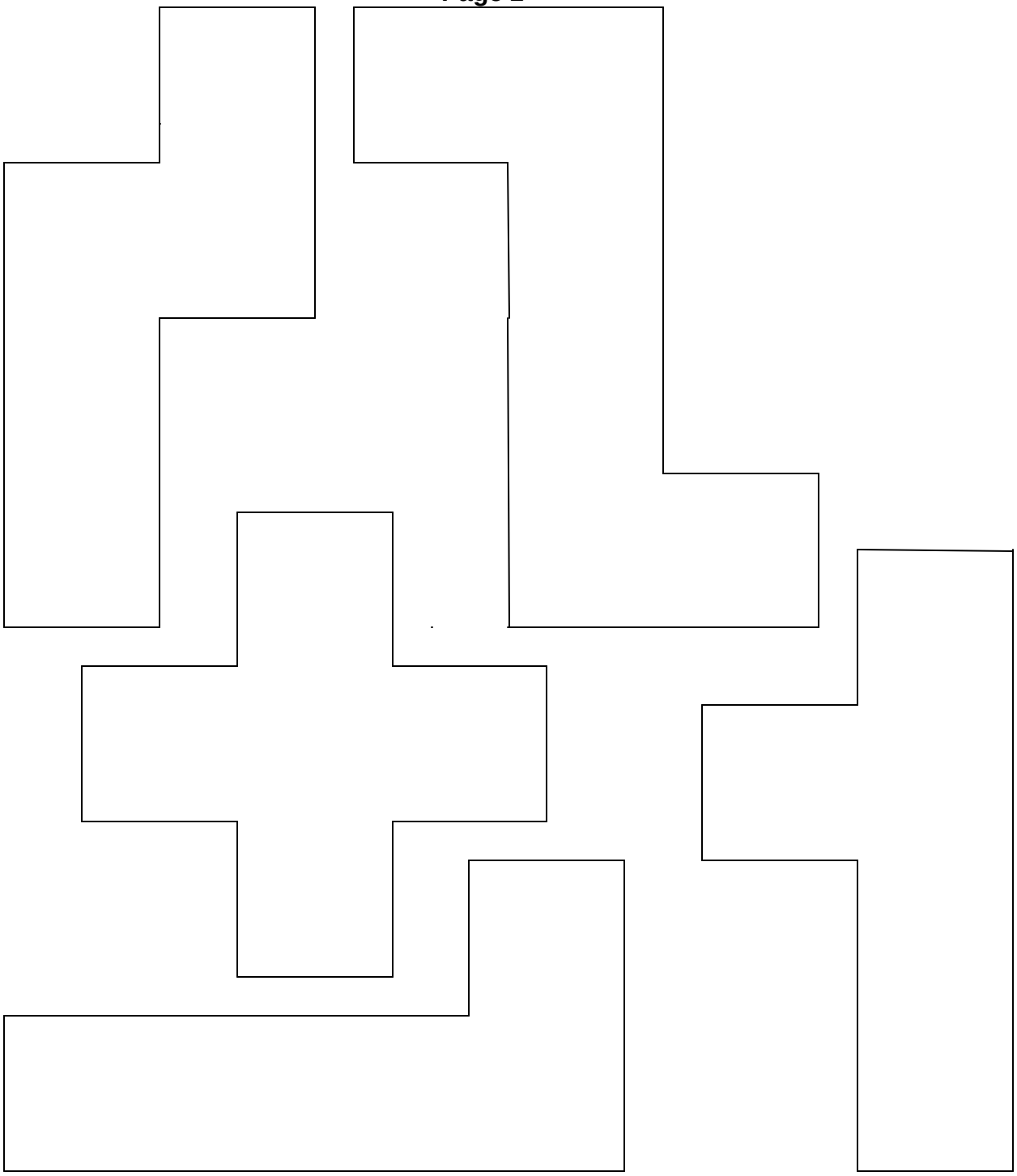


4 x 5 Puzzle Solutions



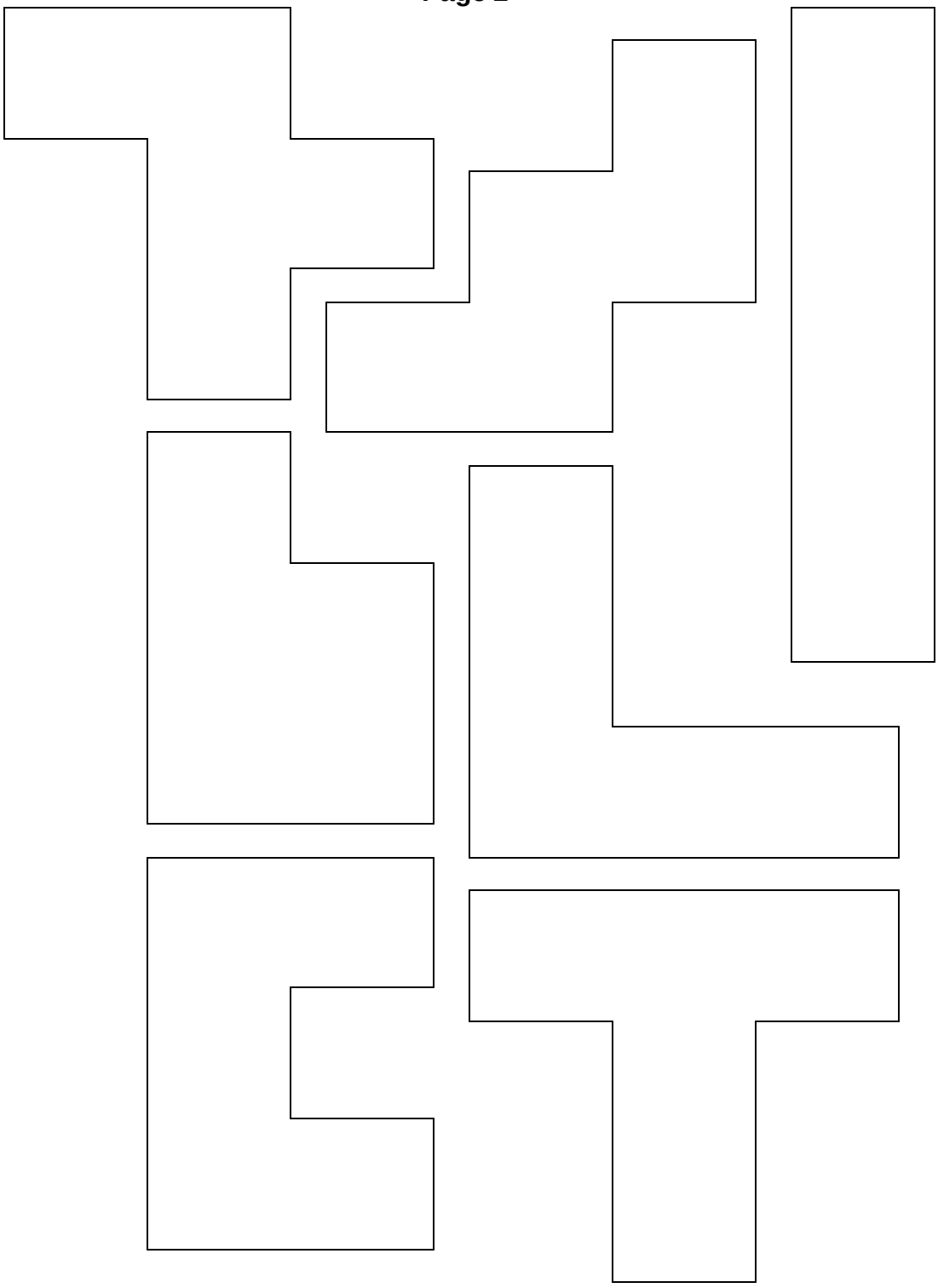
Patterns for Pentominoes

Page 1



Patterns for Pentominoes

Page 2



Activity: Hexominoes

Format: Large Group/Small Group

Objectives: Participants will use spatial visualization to build "hexominoes" with six tiles, testing for figures that are flips (reflections) and turns (rotations) of other figures.

Related SOL: K.11, K.12, K.13, 1.16, 2.22, 3.18, 3.20, 4.17, 5.15

Materials: Tiles, scissors, grid paper, Hexominoes Activity Sheets 1, 2, and 3,, and envelopes or plastic baggies

Time Required: Approximately 15 minutes

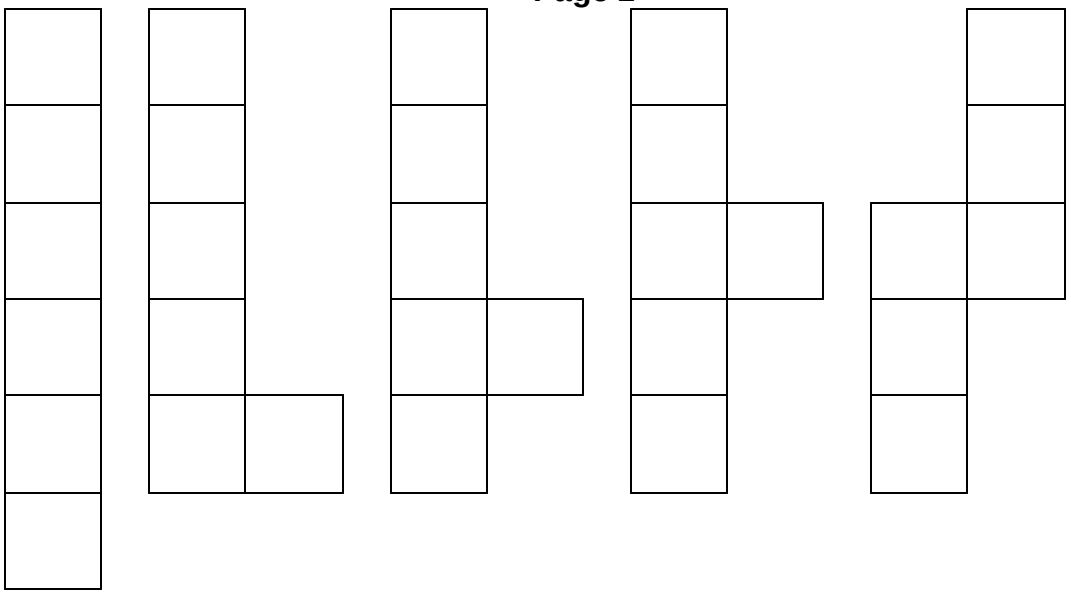
Directions:

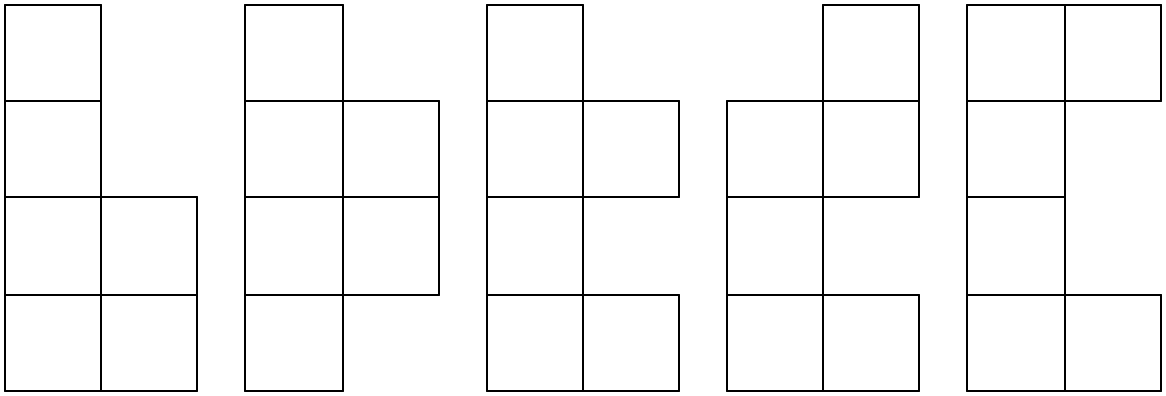
1) Distribute the materials and ask the participants to:
   a) On their own or working with a partner, use six color tiles to find all the possible hexominoes. A **hexomino** is a figure made of six squares, each of which has one side in common with the side of another square.
   b) Record each hexomino on grid paper. When you think you have found all the hexominoes cut them out. Check to make sure that each hexomino is different from all the others.
   c) How many hexominoes did you find? (35) Number them on the back and put them in an envelope. Write your names and the number of hexominoes on the envelope.
   d) Exchange envelopes with another pair. Check that none of their hexominoes are duplicates of one another. Mark any two that you think are exactly the same. Return the envelopes. Check your envelope to see if any duplicates were found.
   e) Decide on a way you can sort your hexominoes.

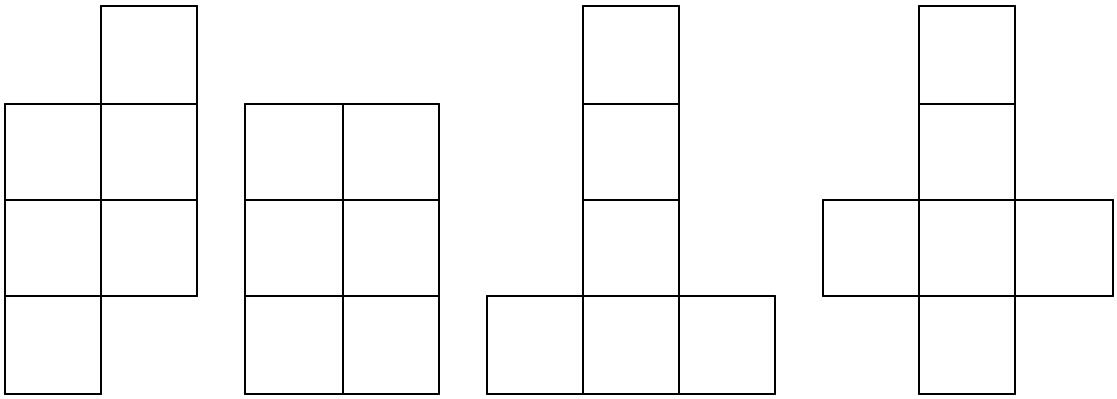
2) Ask one or two pairs to post their hexominoes in an organized way. Use prompts such as these to promote class discussion:
   - Do you think that you have found all possible hexominoes? Why or why not?
   - In what ways do the hexominoes differ from one another?
   - Did you use a strategy to find new figures? If so, what? Note: one strategy would be to start with each of the pentominoes and place one additional tile in each location around the perimeter of each pentomino to generate all of the hexominoes.
   - Did you find any patterns while making your hexominoes? Did you use these patterns when sorting them? If so, how?
   - Did sorting your hexominoes help you find others that were missing? If so, explain.

Hexominoes

Page 1

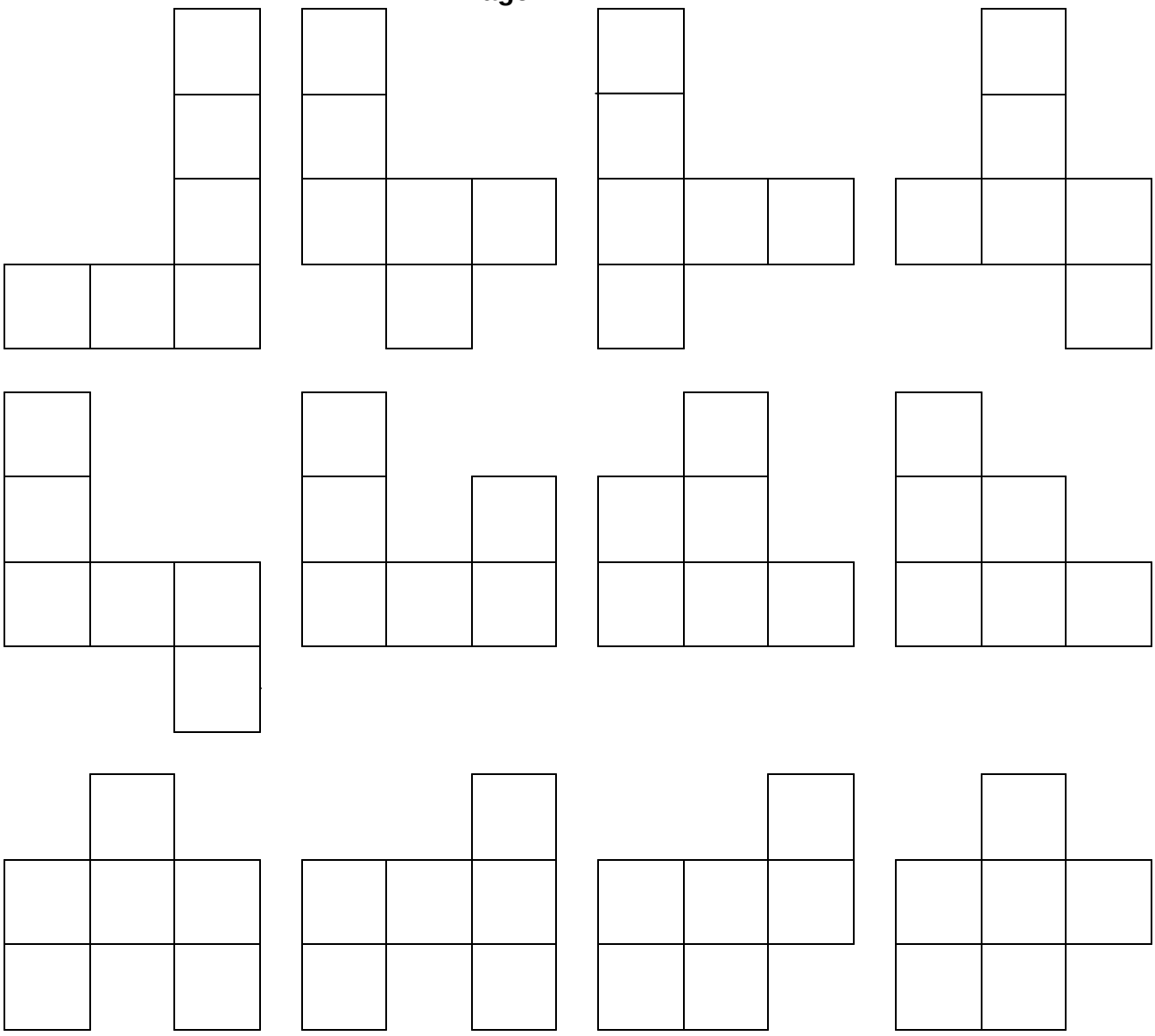






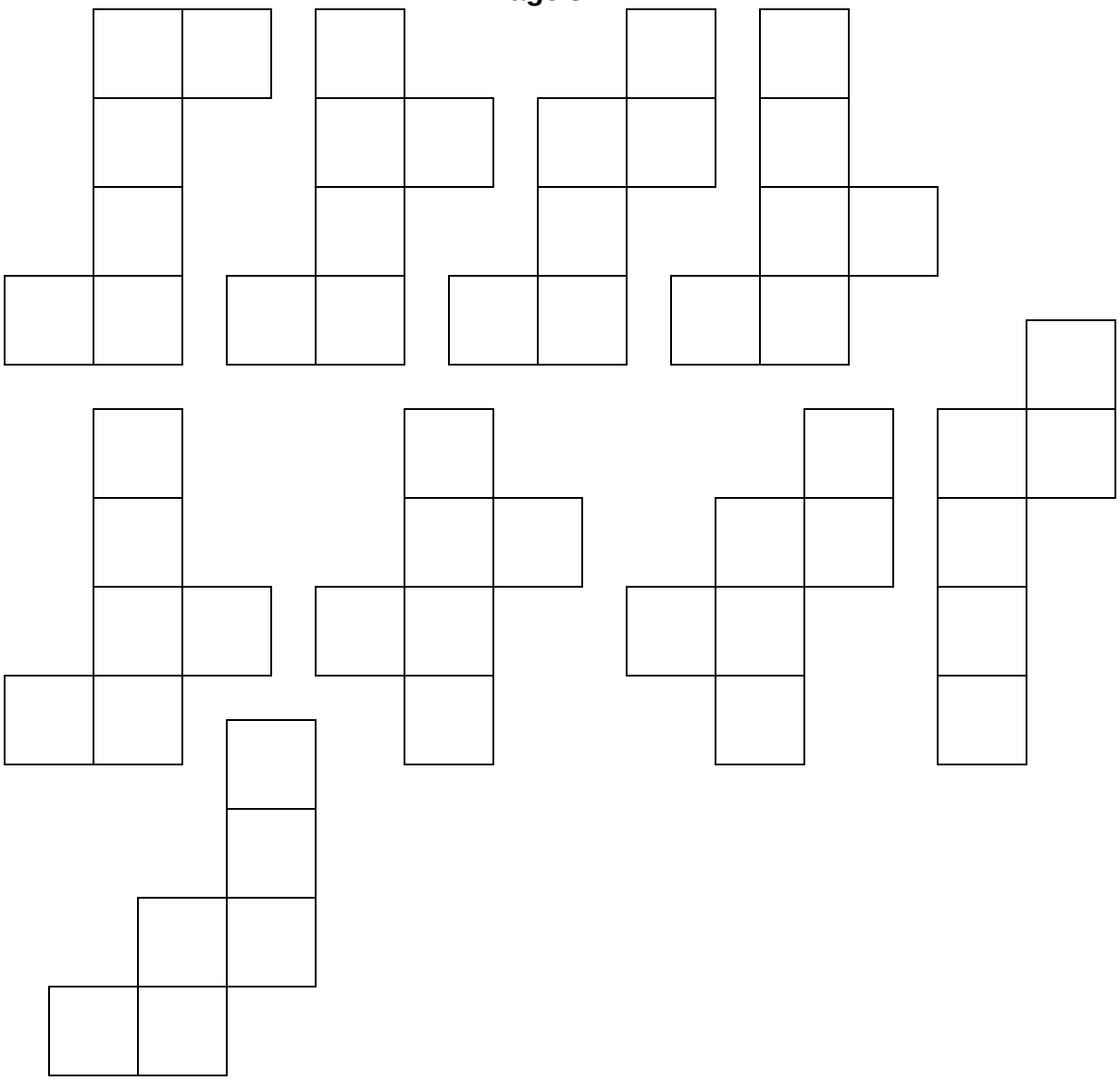
Hexominoes

Page 2



Hexominoes

Page 3



Activity: Perimeters with Hexominoes

Format: Large Group/Small Group

Objectives: Participants will sort "hexominoes" according to their perimeters and look for patterns in their collected data.

Related SOL: K.11, K.12, K.13, 1.16, 2.20, 3.18, 3.20, 4.13, 5.10

Materials: Hexominoes from previous activity, Perimeter of Hexominoes Activity Sheet

Time Required: Approximately 15 minutes

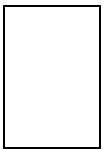
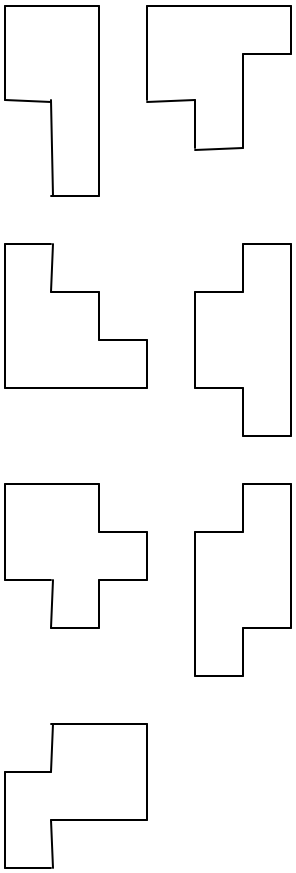
Directions:

1) Ask the participants how they would determine the perimeter of each hexomino. Have them sort all of the hexominoes according to their perimeter and then look for patterns in the collected data.

   Example Patterns:
   - there are no odd numbered perimeters
   - all hexominoes with perimeter 12 include a large square made up of four small squares
   - all hexominoes with perimeter 12 include a rectangle made up of three squares
   - all hexominoes with perimeter 14 include a rectangle made up of two squares
   - none of the hexominoes with perimeter 14 include a large square made up of four small squares

2) Ask the participants to determine the area of each hexomino. Discuss how two figures can have the same area but different perimeters.

Perimeters of Hexominoes

10	11	12	13	14
				**All Others**

Topic: Perimeter and Area, Part II

Description: Participants will explore the relationship between area and perimeter by creating various figures with the same perimeter and different areas or the same area and different perimeter using both one-inch cubes and geoboards. They will also find the areas of rectangles and triangles by counting squares covered by the figures on a geoboard and then develop formulas for area.

Related SOL: 4.13, 5.8, 5.10

Activity: The Perimeter Is 24 Inches. What Is The Area?

Format: Small Group

Objective: Participants will differentiate between perimeter and area, and determine the perimeter and area of various rectangles.

Related SOL: 4.13, 5.8, 5.10

Materials: 24-inch paper strip (collar), 38 one-inch cubes, One-Inch Grid Paper, One-Half-Inch Grid Paper

Time Required: Approximately 10 minutes

Directions:

1) Organize the participants into teams of two or three.

2) Ask the teams to find out how many different rectangular arrays they can make that have a perimeter of 24 inches. Have them make the arrays with the cubes and have them check the perimeter with a 24-inch collar. What is the area of each?

3) Once they find a rectangular array, have them draw its representation on the grid paper and write the perimeter and area for each array.

One-Inch Grid Paper

One-Half Inch Grid Paper

Activity: The Area Is 24 Square Inches. What Is The Perimeter?

Format: Small Group

Objective: Participants will differentiate between the perimeter and area, and will determine the perimeter and area of various rectangles.

Related SOL: 4.13, 5.8, 5.10

Materials: 24 one-inch cubes, One-Inch Grid Paper, One-Half-Inch Grid Paper

Time required: Approximately 10 minutes

Directions:

1) Organize the participants into teams of two or three.

2) Ask the participants to find out how many different rectangular arrays they can make that have an area of 24 square inches. What is the perimeter of each?

3) Once they find a rectangular array of 24 square inches, have them draw its representation on the grid paper and write the perimeter and area for each array.

Activity: Change The Area

Format: Small Group

Objective: Participants will differentiate between perimeter and area and determine the perimeter and area of various figures without dependence on formulas.

Related SOL: 4.13, 5.8, 5.10

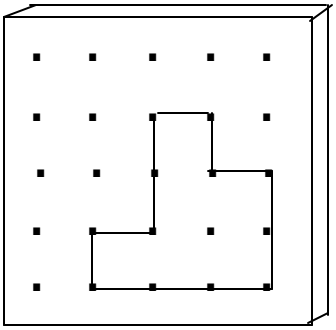
Materials: square geoboards, rubber bands, Geoboard Dot Paper

Time required: Approximately 10 minutes

Directions:

1) Organize the participants into teams of two or three.

2) Have them copy this figure on the geoboard and onto dot paper, labeling its area and perimeter.

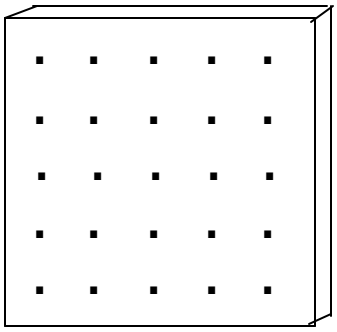


3) Have the participants change the figure to make another figure that has the same area and a larger perimeter, recording it on dot paper with its area and perimeter.

4) Have the participants change the figure to make another figure that has the same area and a smaller perimeter, recording it on dot paper with its area and perimeter.

5) Have the participants make three more figures that have different perimeters but the same area, recording them on dot paper. Discuss the results.

Geoboard Dot Paper



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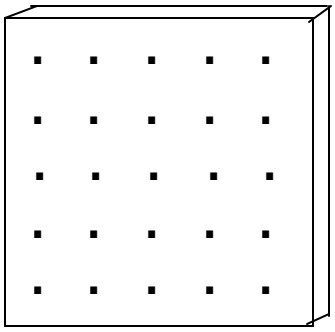

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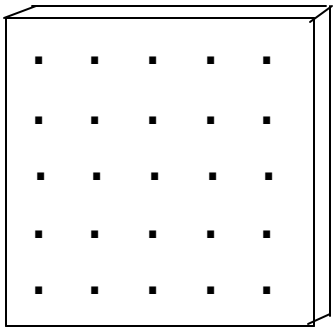

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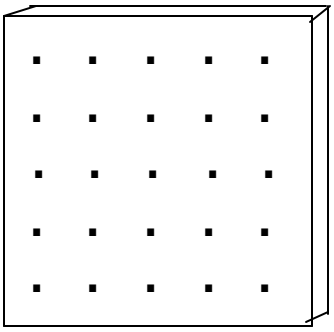

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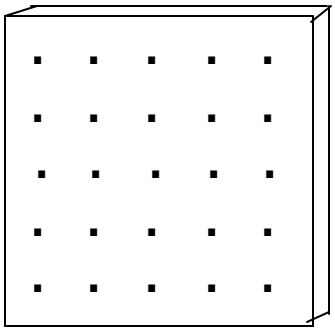

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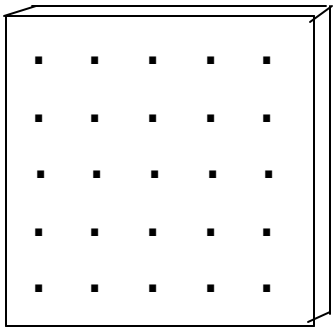

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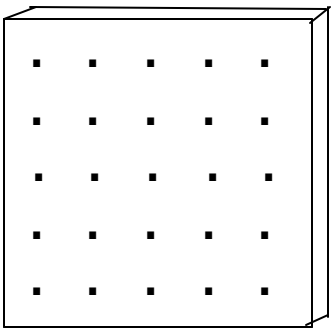

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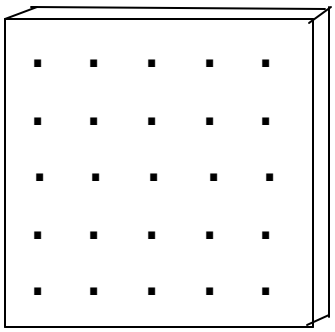

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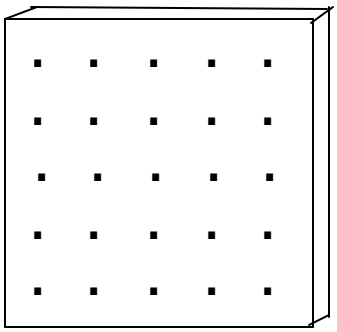


Perimeter: _____
Area: _____

Topic: Coordinate Geometry

Description: Participants will learn how to label and use ordered pairs of positive numbers on a coordinate grid.

Related SOL: 4.18

Activity: Hurkle

Format: Small Group

Objectives: Participants will review number lines through a simple warm-up exercise. One participant will hide the "Hurkle" on a number line for a partner to find. Participants will use vertical number lines, horizontal number lines, and number lines extending from -5 to +5

Related SOL: 4.18

Materials: Hurkle Activity Sheets 1, 2, and 3

Time Required: Approximately 10 minutes

Directions:

1) Divide the participants into pairs

2) Have the first participant draw a number line with 0 as the left endpoint and 10 as the right endpoint.

3) The partner should write down a whole number between 0 and 10 where the first participant can't see it. This number represents the location where the "Hurkle" is hiding.

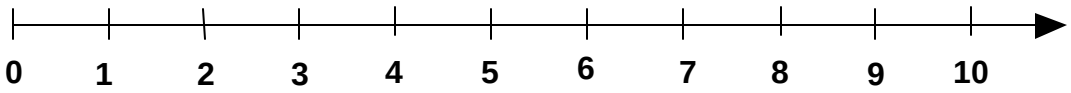
4) The first participant tries to guess the number with the partner responding "higher", "lower", or "perfect".

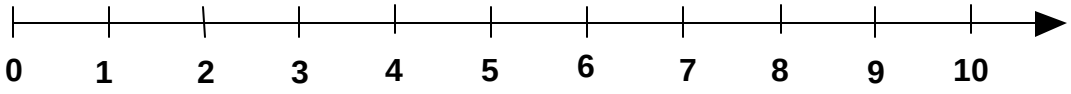
5) Repeat several times, alternating roles, and using vertical number lines, horizontal number lines, and number lines extending from -5 to +5.

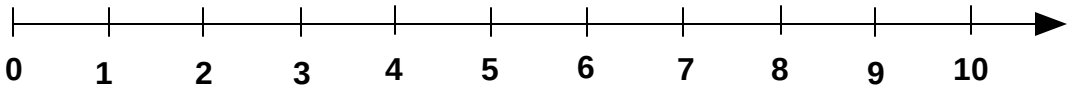
Note: This warm-up is a non-computer version of the excellent old MECC program *Hurkle* for the Apple II and very early MS-DOS computers.

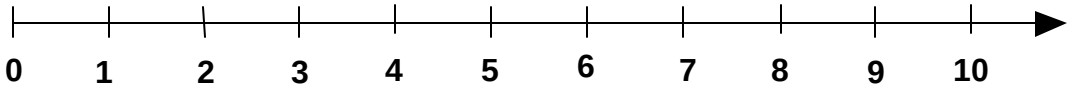
Find the Hidden Hurkle

Page 1



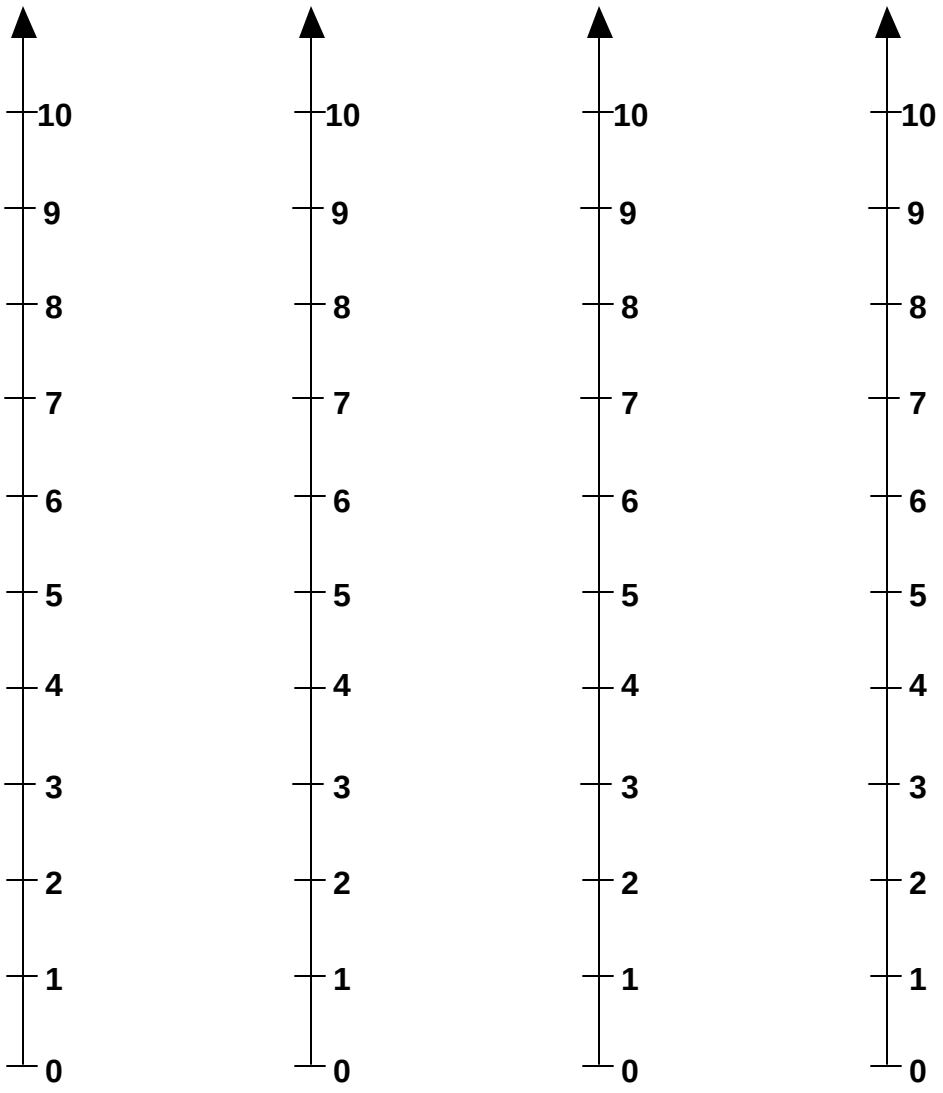






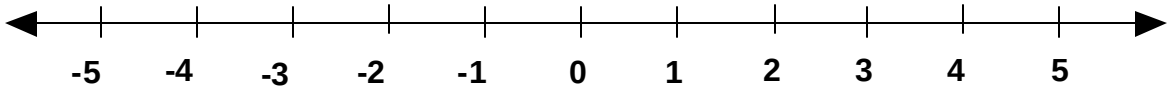
Find the Hidden Hurkle

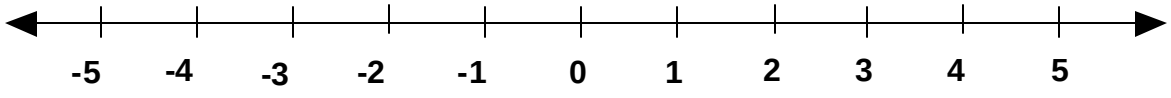
Page 2

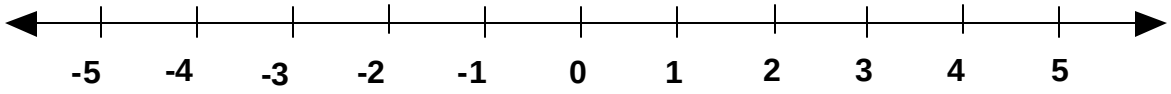


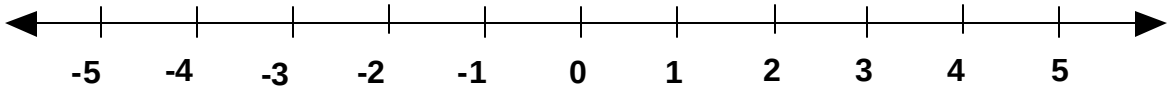
Find the Hidden Hurkle

Page 3









Activity: Two-Dimensional Hurkle

Format: Small Group

Objectives: Participants will learn how to label points on a coordinate grid with an ordered pair of positive numbers and develop problem strategies for finding hidden points.

Related SOL: 4.18

Materials: Find the Hidden Hurkle Coordinate Grid Activity Sheet

Time Required: Approximately 10 minutes

Directions:

1) Divide the participants into pairs

2) The first participant should write down an ordered pair of numbers, each between 0 and 10 hidden from the partner. This ordered pair represents the location where the "Hurkle" is hiding.

3) The second participant tries to guess the ordered pair with the partner responding "go right", "go left and down", "go up", "perfect", etc.

4) Repeat several times, alternating roles

Note: This activity is a further adaptation of the MECC program *Hurkle* for the Apple II and very early MS-DOS computers.

Find the Hidden Hurkle Coordinate Grid